Recent developments in physics

J.P. Wellisch, CERN/EP,
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Outline

- Some (very few for reasons of briefness) hadronic physics highlights
  - really new developments and invention only
- Some highlights on low energy EM physics
- A systematic study of energy loss in standard electromagnetic physics

Some hadronic physics highlights of 2001

- Neutron spectra from pre-equilibrium decay
- Chiral invariant phase-space decay
- Doppler broadening on the fly
- qgs model for pion and kaon induced reactions
- A propagation test for quantum molecular dynamics

Chiral Invariant Phase-space Decay: gamma nuclear reactions

- A quark level 3-dimensional event generator for fragmentation of excited hadronic systems into hadrons.
- Based on asymptotic freedom.
- Local chiral invariance restoration allows us to consider quark partons as massless. We can fold the invariant phase-space distribution of quark partons with the quark exchange (fusion) probability of hadronization.
- The only non-kinematical concept used is that of a temperature of the hadronic system (Quasmon).

The neutron_hp transport models

- Simulate the cross-sections and interactions of neutrons with kinetic energies below 20 MeV down to thermal energies .
- The upper limit is set only by the evaluated data libraries the code is based on.
- We consider elastic scattering, fission, capture and inelastic scattering as separate models
- Neutron_hp sampling codes for the ENDF/B-VI derived data formats are completely generic (not including general R-matrix for the time being)
- Note that for fission there is a quite competitive theory driven alternative model, G4ParaFissionModel.

Data: G4NDL0.2, 3.7

- Are granular selections of data from (alphabetic)
  - Brond 2.1
  - CENDL 2.2
  - EFF-3
  - ENDF/B (VI.0, VI.1, VI.5)
  - ENSDF
  - FENDL/E2.0
  - JEF 2.2
  - JENDL (3.1, 3.2, FF)
  - MENDL-2(P)
- Large parts of the selection is guided by the FENDL-2 selection
- G4NDL0.2 for non-thermal application
- All data at 0K temperature

Models for neutron interaction and thermalization.

- neutron_hp models and cross-sections:
  - Uses the unix file-system to ensure granular and transparent access/usage of data sets.
  - More than 10^9 events run.
  - Uses point-wise cross-sections → no artifacts due to multi-group structure.

Doppler broadening

- Does exact doppler broadening on the fly, based on 0K data ➔ no pre-formatting of data to fixed temperatures, and easy simulation of set-ups with mixed temperatures.
- Adds the doppler bias to the nuclear momentum distribution
- These two last points are to the best of our knowledge not available from any other code.

qgs model for pion and kaon induced reactions

- Pomeron trajectory and vertex parameters tuned to describe elastic, total and diffractive (6% assumed) cross-sections for kaon and pion scattering off nucleons.
- No tuning on final state distributions.
- A few plots to illustrate the quality of prediction

A propagation test for QMD development

- Some characteristics of QDM:
  - A kinematical cascade with detailed modeling of the nucleus.
  - Nuclear Hamiltonian calculated from 2 and 3 body potentials of all hadrons present in the system.
  - Solving the equation of motion by integrating this time-dependent Hamiltonian.
  - Scattering term in terms of localized interactions and decays.
  - Etc..

Some low energy EM physics

- Energy loss of protons and ions in matter, a courtesy of M.G. Pia

Latest results on electromagnetic physics

- A courtesy by L. Urban

Conclusions

- Physics modeling, physics validation, and physics research is both scope and concern of all geant4 physics working groups.
- The main focus is on shower physics, and dosimetry, but many other areas are considered.
- ALL efforts that want to contribute to physics in the geant4 context are welcome.
  - Note that we strive to make sure that individual activities are integrated to avoid duplication of work, but also trivial mistakes